Space Weather Technical Forecast

Issued on Tuesday, 25 July 2023 at 01:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance R1/R2 blackouts throughout. Chance of G1 Minor geomagnetic storms late day 2 and day 3 (26th/27th July).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with peak flares of C9.1 at 24/0426 from AR3373, C8.5 at 24/0542 UTC from AR3372 (over the limb) and C8.4 at 24/0021 UTC from AR3382/AR3383. These latter two regions have been numbered due to the splitting of AR3379, with this original spot now associated with the leader and nearby small reverse polarity trailer spot. AR3373 is now approaching the western limb with any analysis difficult. AR3380 in the southeast and AR3376 in the northwest are the main developmental regions, with both seeing the emergence of a number of smaller spots around their largest main spot. AR3380 is also a longitudinally wide region, near the east limb, and may both reveal more complexity but also be split into two separate regions.

No Earth-directed CMEs were observed in the last 24 hours, however there were two events of interest. The C8.4 flare from AR33782/AR3383 resulted in a faint and weak CME, however this has been modelled as missing behind Earth. A very fast far-sided full halo eruption was then visible in SOHO C3 coronagraph imagery from 24/1800 UTC.

Solar Wind / Geomagnetic Activity: Observations by ACE at L1, are indicative of a weak connection to the fast wind, most likely from coronal hole 27 on the northern disc. Solar wind speeds varied from background to slightly elevated at 350-450km/s. Density was below average. Interplanetary magnetic field (IMF), Bt, was weak and steady at 5-7 nT with north-south component variable and ranging from +6 to -6nT. Phi angle was predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux rose after 24/1820 UTC in response to the large far-sided event. This peaked below the S1/Minor Radiation Storm threshold (10pfu) at 7.55pfu at 24/2055 UTC before very gradually and erratically easing thereafter. GOES16 high energy (greater than 2MeV) electron flux was Background to Moderate throughout, with the associated 24-hour integrated fluence persisting below the Active threshold. A slight rising trend was observed, with 7.63e6 total pfu at 24/2100 UTC

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with a chance of isolated M-class flares.

Solar Wind / Geomagnetic Activity: A CME from 23 Jul due to the C7 flare of AR3376 may give a glancing impact either late day 2 or early day 3 (26-27 Jul). Otherwise current weak fast wind conditions are expected to persist. A further weak coronal hole HSS may arrive later on day 3 (27 Jul) or day 4 (28 Jul) however this is low confidence. Mainly Quiet geomagnetic activity at first, with a chance of isolated Unsettled to Active intervals. This increasing to give a period Unsettled to Active, with a chance of G1 Minor storms with any CME arrival, either late day 2 or early day 3 (26-27 Jul) and a slight chance with any further HSS enhancement later day 3 or 4 (27-28 Jul).

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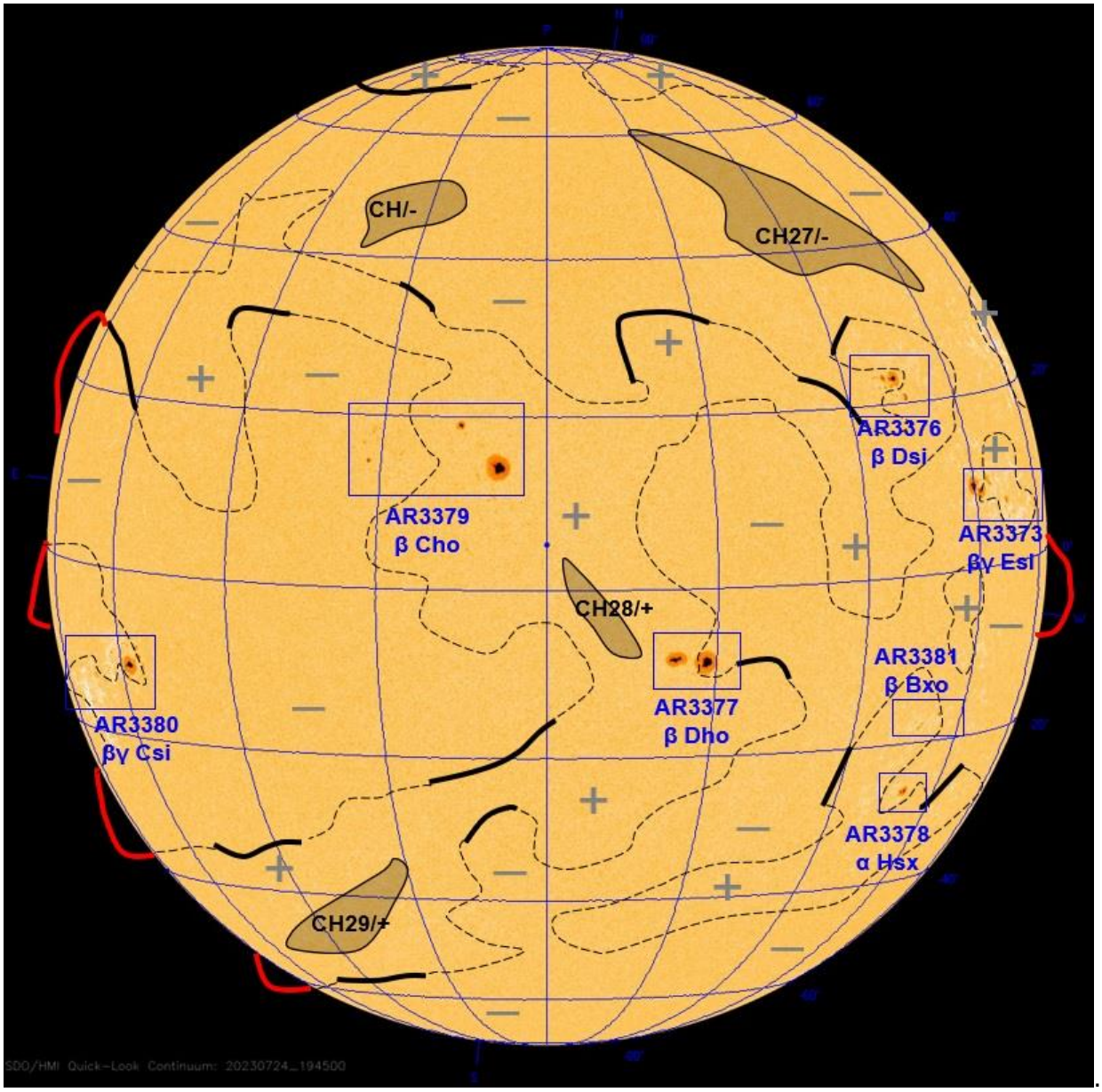
Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux is expected to continue declining towards background, with any further events from the far-side unlikely to significantly increase levels. Observed values may increase ahead of any CME arrival however, and there remains a slight chance of proton flux increasing from any significant flares that occur. Radiation storms are currently not expected however. The high energy (greater than 2MeV) electron flux is expected to persist at mainly background levels, but with a chance of becoming more persistently moderate, perhaps rising to high once any CME influence recedes day 3 (27 Jul). Active fluence is currently not expected.

Figure 1. Solar Analysis Valid 24/2000 UTC (AR3379 now split to AR3379/82/83).



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The long period C7.4 flare from AR3376 at 23/1457 UTC produced a partial halo CME, which is forecast to give a likely glancing impact either side of midnight on day 2-3 (26-27 Jul). This has some notable uncertainty on the arrival time, due it being a likely glancing impact and a coincident, and uncertain, coronal hole enhancement. The impact has therefore been delayed over pure Enlil model expectations slightly. There is also a broad shock from this CME, which may enhance conditions ahead of this arrival.

Otherwise current slightly elevated winds are expected to continue until any CME arrival, with Earth likely connected to fast wind of CH27/- in the northern solar hemisphere. A further enhancement from any fast wind associated with CH28 is possible on day 3 or into day 4 (27-28 Jul), however this is very low confidence given the small and indistinct nature of this feature and a more westward location compared to the previous rotation.

Mainly Quiet geomagnetic activity at first, with a chance of isolated Unsettled to Active intervals. This increasing to give a period Unsettled to Active, with a chance of G1-Minor storms with any CME arrival, either late day 2 or early day 3 (26-27 Jul) and a slight chance with any further HSS enhancement later day 3 or 4 (27-28 Jul).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	30	30	10
Strong	G3	No	1	2	2	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/1915	Partial	C8.8 flare	NW AR3376	735	27/0001 UTC	Low confidence. Glancing impact expected.

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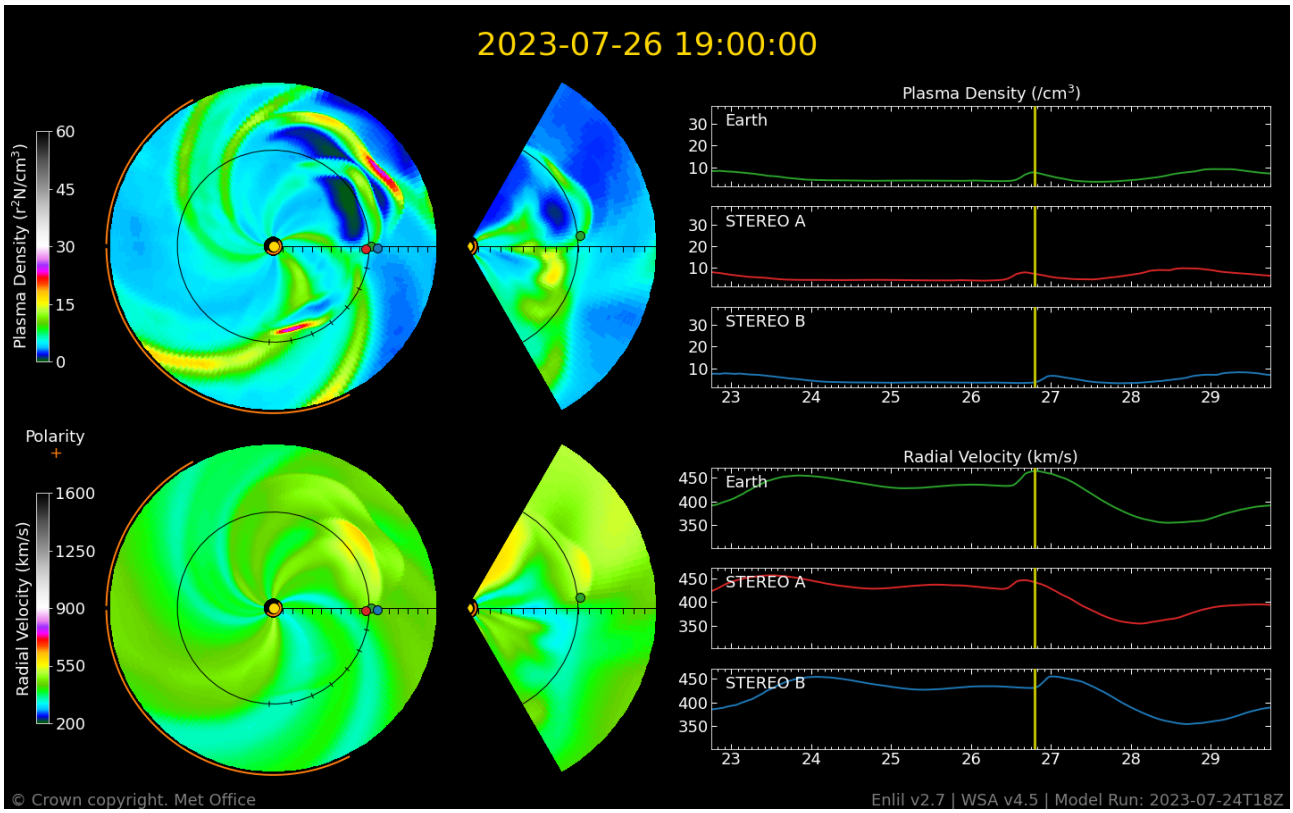
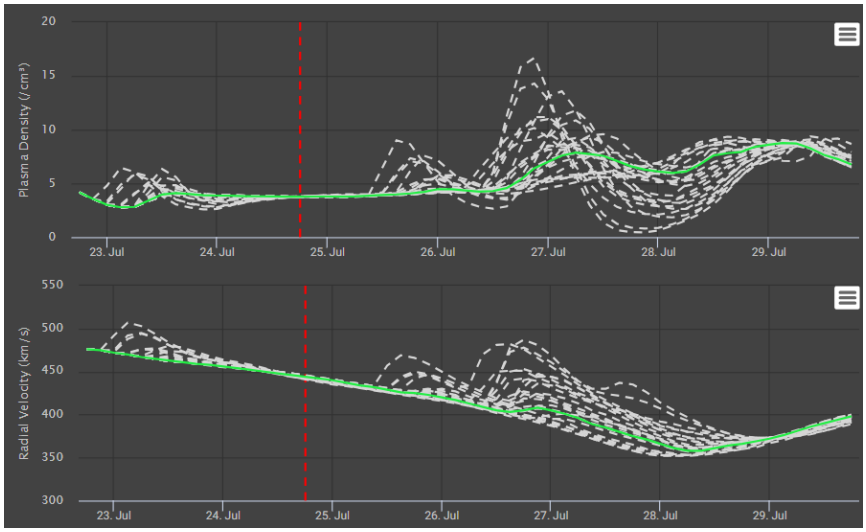
Figure 2: Enlil and ensemble showing CME arrival earlier than currently forecast, due to CH HSS inclusion. Ensemble showing wide uncertainty, with a couple of other missing CMEs also adding to this low confidence.





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Radio Blackouts - X-Ray Flares:

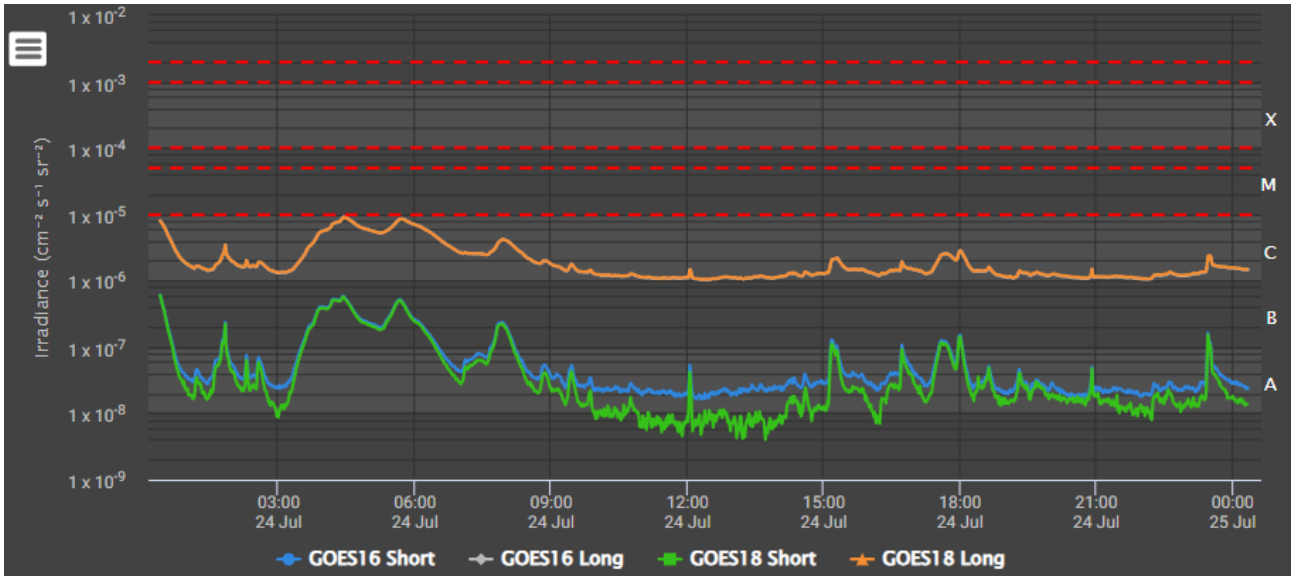
There are currently nine active regions on the disc, with Low activity observed, although this included three C8 flares. Activity is likely to be Low to Moderate, with isolated M-flares likely.

AR3380 in the southeast is potentially the most likely flare candidate, with increasingly complexity becoming apparent, or developing as it rotates into view from the southeast limb. This region dominated by a leader with moderately sized umbra, surrounded by a proliferation of smaller and less mature spots. The trailer is potential a separate region, but is currently considered to be a broad plage area with much smaller individual spots within it, resulting in a wide, but complex region. This complexity is also indicated through significant looping evident in SDO imagery. AR3376 has also exhibited significant growth, with the emergent of a leader spot to the south of what was a mature unipolar region. Further development remains possible with this region. AR3373 is the other main flare candidate, however this is now hard to analyse as it approaches the western limb. AR3372, in the northern central disc has now been split into three separate regions.

The other regions are generally simpler, but moderately sized. This includes AR3379 which has now been split into three simpler and smaller regions (AR3382 and AR3383).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	40	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray Flux



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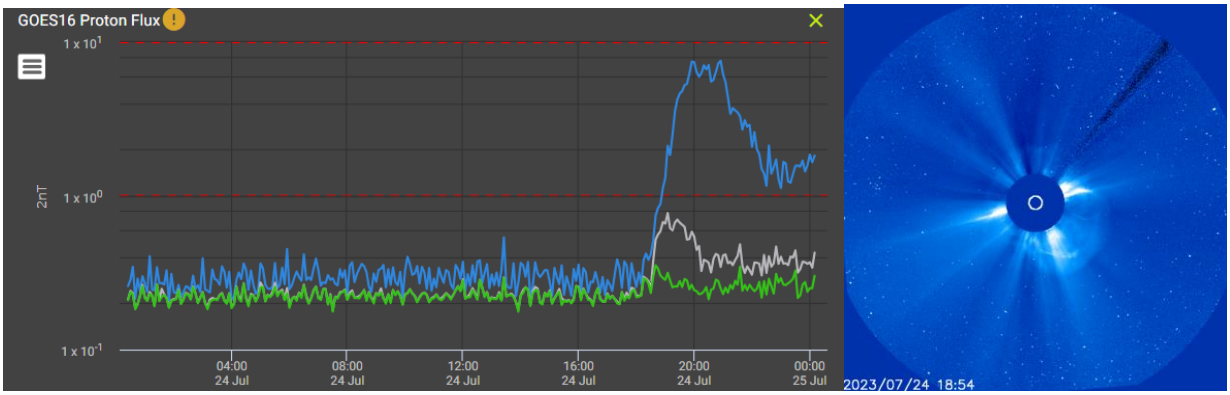
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 became enhanced on 24 Jul due to a large far-sided eruption, from what was likely AR3363 which is now far around the western limb and approaching the far-side centre disc. This increase peaked just below the S1 threshold at 7.55 pfu before gradually easing. These above background proton levels are likely to only gradually and erratically ease towards background through the coming days, and some increase is possible day 2 (26 Jul) ahead of any CME arrival.

Further enhancement from this region are considered unlikely, but cannot be completely ruled out on day 1 (26 Jul). There is also a potential for any significant flares from the regions on the disc to give a slight increase in observed values, with a slight chance of approaching the S1 threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10 MeV, >50 MeV and >100 MeV Proton Flux. Far sided CME shown below from SOHO-c3.



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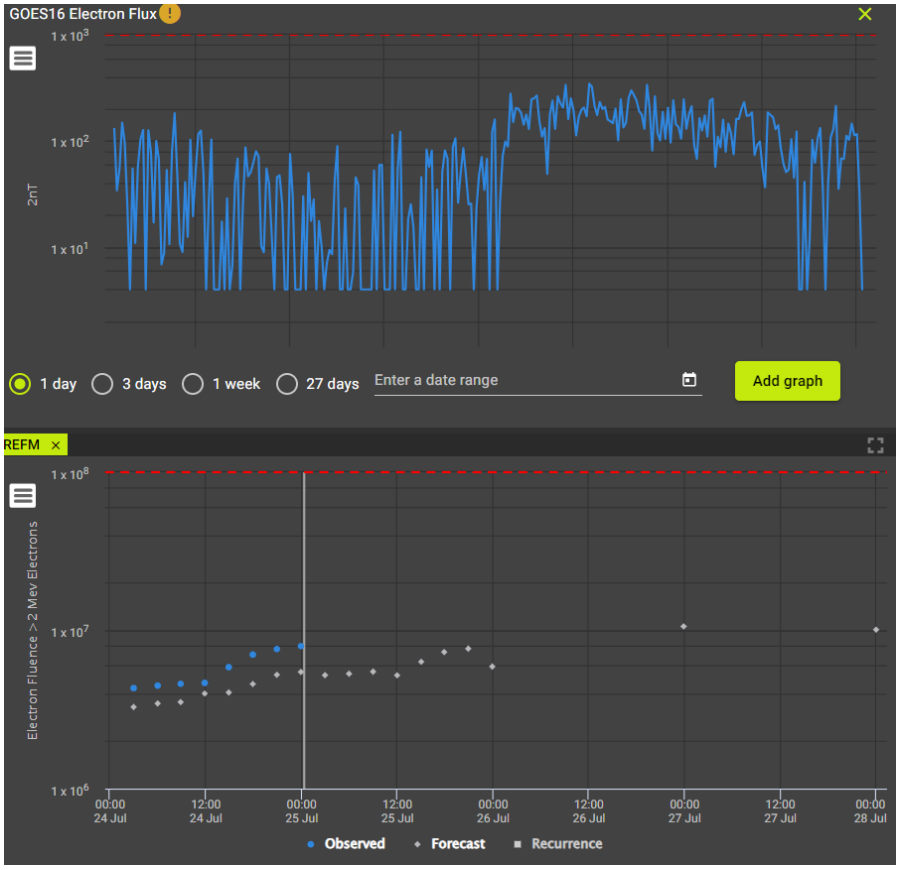
High Energy Electrons Event (≥ 2MeV):

High energy electrons (greater than 2MeV) are at Background to Moderate. No significant enhancements are currently expected, but may recover to be more persistently Moderate, perhaps briefly High levels day 4 (28 Jul) depending upon any CME arrival either late day 2 or early day 3 (26-27 Jul), and how geoeffective any impact is.

24-hour electron fluence is most likely to remain below the Active (1e8 integrated pfu) threshold throughout the period, as indicated in MOSWOC REFM. A rising trend is likely later day 3 and through day 4, once any CME influence subsides, depending on the extent on any CME impact that occurs.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 >10 MeV Flux and associated fluence with REFM



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